Problem Statement and Goals
RoCam

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Table 1: Revision History

Date	**Developer(s)**	**Change**
Sept. 8, 2025	Jianqing Liu	Initial Draft
Sept. 9, 2025	Zifan Si	Details Elaboration
Sept. 10, 2025	Zifan Si	Fix based on teammate suggestion
Sept. 10, 2025	Jianqing Liu	Refine inputs, outputs, and goals
Sept. 12, 2025	Jianqing Liu	Update Depolyment Environment
Sept. 13, 2025	Xiaotian Lou	Update Citation
Oct. 4, 2025	Zifan Si	Fix based on TA feedback

1 Problem Statement

The problem statement outlines the motivation and context behind our project, ROCAM (High Performance Vision-Guided Rocket Tracker). It defines the specific engineering problem of achieving reliable, real-time visual tracking for small-scale model rockets using a gimbal-mounted optical camera system. It also identifies the inputs and outputs of ROCAM, such as live camera feeds, gimbal state data, and stabilized video streams, and states the performance objectives and key stakeholders involved in its development. The goal is to enable accurate mid-flight observation for analysis of staging and parachute deployment, thereby improving both safety and performance in future rocket launches.

1.1 Problem

In model rocketry, two of the hardest engineering problems are staging failures and parachute tangling. These problems are hard to study because they happen in mid-flight, where direct observation is limited. Without reliable tracking, engineers cannot fully understand these failures or design better solutions. As a result, recurring issues remain unresolved, slowing progress in both safety and performance of future rockets.

Model rockets travel at very high speeds, sometimes faster than Mach 3 and over 100 km in altitude (Space Concordia, 2025). Under these conditions, manual camera tracking is not possible.

Tracking a small model rocket is even harder than tracking large rockets such as the Falcon 9. Smaller size and uncontrolled launch conditions make accurate detection and continuous tracking much more difficult.

Some commercial tracking systems exist (AVe, 2021), but they lack the speed and precision needed for small, fast-moving rockets. To address this gap, our project, ROCAM, aims to develop a real-time camera tracking system that can automatically follow model rockets during flight for clear mid-air observation.

1.2 Inputs and Outputs

- **Inputs**
  - Realtime camera feed of the rocket during flight
  - State information from the camera gimbal (a motorized mount that stabilizes and aims the camera)
  - Manual camera gimbal adjustment commands from user
- **Outputs**
  - Commands that move the camera gimbal to keep the rocket in frame
  - Real time video preview for the operator
  - Real time stabilized video output to the live streaming equipment

1.3 Performance Objectives

- The system should be able to process a 1080p 60 fps input video feed from the camera
- The System should be able to output 1080p 60fps to the live streaming equipment
- Real time video preview should be at least 15fps

1.4 Stakeholders

Direct Stakeholders

1. **McMaster Rocketry Team**: The primary end users who will deploy the system during launches. They rely on accurate real-time tracking to analyze staging events, parachute deployment, and overall flight performance.
2. **Faculty Supervisor**: Provides technical guidance, project oversight, and mentorship. Dr. Shahin Sirouspour serves in this role, ensuring that the project aligns with academic standards, engineering best practices, and capstone deliverable expectations.

Indirect Stakeholders

1. **Aerospace Engineers and Researchers**: Benefit from high-quality flight footage to validate models, improve rocket designs, and support experimental research.
2. **Event Organizers and Safety Officers**: Rely on reliable tracking for live monitoring of rocket flights, particularly for confirming parachute deployment and safe recovery during launch events.
3. **Engineering and Robotics Community**: May adapt the system's design principles for other domains requiring precise tracking of fast-moving objects, such as UAV navigation, sports analytics, or autonomous robotics.
4. **Potential Commercial and Industrial Users**: Could adopt the system for broader applications in surveillance, wildlife monitoring, or industrial inspections where real-time vision-guided tracking is valuable.

1.5 Deployment Environment

- Outdoor rocket launch sites with variable lighting, wind, and dynamic backgrounds.
- Indoor lab-based testing and demonstration for development and evaluation.

2 Goals

The goal of this project is to design and implement ROCAM, a real-time camera tracking system that automatically detects and follows small-scale model rockets during launch, ascent, and descent (apogee ¡ 200 m). The system aims to maintain a stable visual lock on the rocket using a motorized gimbal, process a 1080p 60 fps video feed in real time, and output both live and recorded stabilized footage. By meeting these goals, ROCAM will provide clear mid-flight visual data to support analysis of staging events, parachute deployment, and overall flight performance.

3 Stretch Goals

- Handle 4K 60fps camera stream.
- Include functionalities to control the zoom and the focus of more advanced cameras.
- Integration with a full-size gimbal developed by the McMaster Rocketry Team.
- Track high-powered model rocket launches (apogee 3km+), while achieving all the performance objectives listed in Section 1.3.

4 Extras

In addition to the core goals of ROCAM, our team plans to include a few value-added components that enhance the overall quality and usability of the system. These extras aim to demonstrate practical integration between hardware and software, improve accessibility for end users, and provide clearer insight into the system's design and operation. The selected extras include the design of the control circuit used to drive the gimbal actuators and the creation of a user instructional video for system setup and operation.

4.1 Circuit Design

As this project requires the use of a mechanical gimbal, an electrical circuit is needed to interface between the host computer and the gimbal actuators. The circuit will handle motor control, feedback sensing, and communication with the main software to enable precise and stable camera movement.

4.2 User Instructional Video

An user instructional video will be created to help potential users to understand how to use the system.

Appendix — Reflection

Our team collaborated effectively on this deliverable, maintaining clear communication and giving constructive feedback to improve each section. The writing process went smoothly overall, and adding the "Performance Objectives" section helped clarify what we meant by high performance and made our project goals more specific. Some challenges arose, such as defining what "high performance" should mean for our system and deciding how complex the implementation should be, but we discussed these issues together and reached a clear, realistic definition supported by measurable goals. Learning to write in LaTeX and follow the template format also took time, but sharing examples and helping one another fixed most formatting issues quickly. As the main editor, keeping everyone's updates synchronized before the deadline was difficult, so we set small internal deadlines and used GitHub to track edits efficiently. Overall, the team worked cohesively, divided tasks fairly, and refined the document through supervisor and TA feedback to produce a clear and well-organized final version.

References

AI Auto Tracking PTZ Camera TR3XX Series User Manual. AVer Information Inc., October 2021. Version 1 (2021-10-15).

Space Concordia. Space concordia rocketry. https://web.archive.org/web/20250717115148/https://spaceconcordia.ca/rocketry, 2025. Archived 2025-07-17; accessed 2025-09-13.